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CONSTRUCTION PROBLEMS IN MULTI-FAMILY RESIDENTIAL BUILDINGS

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CONSTRUCTION PROBLEMS IN MULTI-FAMILY RESIDENTIAL BUILDINGS

(A DOCUMENTATION AND EVALUATION)

Submitted to

ONTARIO NEW HOME WARRANTY PROGRAM

and

CANADA MORTGAGE AND HOUSING CORPORATION

by

Robert G. Drysdale, Ph.D., P.Eng.
Drysdale Engineering and Associates Limited
69 Reding Road, Ancaster, Ontario, L9G 1M9

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Canada

CONSTRUCTION PROBLEMS IN MULTI-FAMILY RESIDENTIAL BUILDINGS

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The assistance of Mr. S. Bohm in the preparation of the computer programme and the tracking down and entry of building details and problem files was essential to the successful completion of this project.

SUMMARY

A computer programme has been developed to facilitate documentation of design and construction features of multi-family residential construction. This programme also has provision for listing of building envelope problems including location and severity. It is incorporated in the structure of Data Base IV and is designed to run on a micro computer compatible with an IBM 286 with hard drive and 640 minimum RAM.

For convenience of data input, both the building description and problem record have been organized through extensive sets of menus. This format greatly reduces the effort required for data input and also ensures a consistent form and organization of data. This latter aspect is essential to be able to study the information in an organized manner and to be able to summarize data.

Programming and the set up of the data base allows for study of various relationships between building details and between problems. At the simplest level, the number of buildings having a particular set of construction details and/or problems can be counted. The location, severity and additional comments related to these problems can also be output. On a more complex level, cross comparisons can be formulated to identify buildings that possess certain combinations of details or problems or some mix of details and problems.

Data was collected using files on condominium construction available at the Ontario New Home Warranty Program Regional Offices. These files contain information compiled by Condo Conciliators regarding problem complaints, confirmation and resolution. In many cases the repair costs were also listed. Plans and specifications for the buildings were generally not available and arrangements had to be made with the designer, contractor or condominium board to review the plans to provide most of the input of construction details. In slightly one third of the cases, a site visit was also included to check on certain details and to gain an overall impression of construction quality.

Extensive studies of the data and cross-comparisons have been completed and provide very relevant information leading to recommendations for improving both the design and construction of multi-family residential construction. In some cases, the recent completion of construction may be a factor in the existing files containing relatively little evidence of problems. However, for both these buildings and other older building with more extensive files, analysis of the design and construction details leads to the ability to predict likelihood of future problems.

The most obvious and important observation of this study is that plans and specifications related to the building envelope were shown to be consistently deficient. Whereas poor practices were occasionally shown, the more usual case was the absence of required information. They were particularly lacking in many important details. In fact only one set of plans could be identified as being comprehensive. Many would be rated as quite inadequate.

Most files are less than 2 years old and therefore it is not surprising that most of the problems reported relate to rain penetration. Freeze-thaw damage, corrosion, spalling due to lack of movement joints, more extensive staining and damage due to in-wall condensation are likely to become more prevalent at longer times from initial construction. This conclusion is drawn from some initial signs of damage and from review of the design details. Whereas some faults such as poor quality windows might be related to attempts at significant cost cutting, many design details such as specification of proper ties, flashing, cavity width, weepholes, stud connections, balcony curbs, and continuity of air and vapour barriers and thermal insulation are more a matter of attention to detail rather than significant cost saving.

The state of knowledge on many aspects related to design and performance of building envelopes has been reasonably well defined for many years. The apparent widespread lack of application of this knowledge in the design and detailing of building

envelopes leads to the conclusion that steps should be taken to dramatically improve this situation. It is recommended that hard copy or computer based data files be filled in by designers to ensure that the most important features of design have in fact been thought through and specified. In order to facilitate the specification and proper detailing, it is recommended that model (or standard) details and specifications be made available so that designs can either use these directly or modify them to suit their specific applications.

This study has provided sufficient information on both existing problems and other existing deficiencies in design detailing to cause significant concern about both the short term and long term performance and the maintenance and remedial costs for many of the condominiums. Conversely there are examples of well detailed and carefully built condominiums that are performing very well. With high level of attention to detail and proper provision for quality assurance, this is achievable. Therefore it is recommended that a major continuing effort of ONHWP and CMHC should be in the area of provision of advice on proper design and construction practice. Also implementation of procedures to ensure adequate quality control is necessary. Perhaps this could be accomplished by using third party inspection and final audit independent of either the contractor or board.

It is apparent that information already available has not yet been adopted by a fairly large segment of the building industry. Therefore it is important that efforts be continued to develop programmes to help designers and builders produce satisfactory buildings. There is still a major need for provision of opportunities for practical education and for production of easy to read, easily accessible technical information.

1. INTRODUCTION

The frequency and magnitude of requirements for remedial work on relatively new multi-storey condominium buildings provided some of the incentive to undertake a study to identify the main types of problems and to try to correlate these with corresponding building systems or design or construction practices. Regardless of whether remedial costs are born by the original contractor, the warranty program, or by the owner, it is in everyone's interest to take steps to minimize the problems and the resulting costs. In order to be able to obtain the most benefit from steps to be taken to reduce costly problems, it is necessary to identify the problems that are most prevalent and which produce the largest costs, dislocation of residents or long term loss of value of the property.

Surveys of builders, designers and building officials have in the past proven to be relatively ineffective as a comprehensive source of types, frequencies, and causes of problems in buildings. Therefore it was decided that the information would have to be gathered by a research team with knowledge of structural and building envelope systems and experienced in evaluation of performance. The concept of the original proposal was that files on condominiums registered with the Ontario New Home Warranty Program would be used as the data source for problems that have required remedial work in recent construction. These files served that purpose very well but because there was no need, information on the design and construction of the buildings was not available. Therefore, to document types of construction and relevant design and construction details, it was necessary to contact the original contractor and/or designer to borrow plans and specifications. Also approximately one third of the 52 buildings included in the study were visited to get a general impression of the quality of construction and to provide additional information on select features such as mortar in movement joints, openness of weepholes through to the face of the veneer, effiorescence, staining, etc.

The original objective was to include 40 buildings in the survey. Of the 52 buildings surveyed, files on both the design details and the problems were completed for 43 buildings. Four additional buildings have complete design details files but are too new to have problem files. Problem files have been reviewed for 5 buildings for which design information was not obtained.

2. ORGANIZATION OF THE STUDY

2.1 Organization of the Data

2.1.1 Introduction

Initially it was planned that input on building design details and problems would be organized using a micro-computer spreadsheet programme and therefore it would be necessary to have a Survey Form which was sufficiently detailed to permit consistent gathering and entry of this information. However as the work of preparing this form progressed it became apparent that, due to its length and the complexity of descriptions of building details and problems, use of the spreadsheet programme itself as the survey form would be the most effective approach.

2.1.2 Form of the Spreadsheet Data Base

It was decided to use an up-to-date spreadsheet programme possessing reasonable versatility and one with which potential users of this research would likely be familiar. The Ashton Tate dBase IV was chosen. The intent is that special computer or dBase knowledge would not be required for future data entry or study of the data. For this reason and so that data entered by several different people would be consistent, use of menus for data input was selected. This is in fact an essential feature if in-depth correlations of problems with building details are to be possible.

2.1.3 Organization of the Spreadsheet Data Base

There are two types of data bases as indicated by items 1 and 2 below.

Building Problem Survey

1 - Define/Change Building Details
2 - Define/Change Problems
3 - Define/Change Search Logic, 2
4 - Define/Change Search Output, 3

5 - Proceed With Search
P - Output to File, off
X - Exit

The first provides a means for listing the building design and construction details and has the main menu shown below that permits specific aspects of the building to be input or edited without having to search through other information.

Building Problem Survey

Edit a Record

1 - Site Details
2 - Design and Construction
3 - Outer Wall System
4 - Inner Wall System
5 - Masonry Backup
6 - Steel Stud Backup
7 - Wall Ties
8 - Movement Joints
9 - Underground
0 - Roof
P - Problem Menu
X - Exit

The first of these choices, Site Details is the only part of the programming that is not menu driven. It includes information such as location of building, address, number of storeys, storey height, etc. and can be included as parts of later searches or correlation studies. For example, building with postal codes starting with L, or starting with either L or K, or starting with L8 etc. could be examined for certain combinations of building details and problems. When any of items 2 to 0 are selected, a listing of relevant types of descriptions appears on the screen such as is shown below for selection No. 4 "Inner Wall System". Each item on this list has its own menu which pops up on the right as the cursor

is moved to the appropriate item on the list. The menu shown is for the "air barrier" item on the list.

Inner Wall Details

Insulation (1).....	Rigid
Location (1).....	Exterior of Backup
Connection (1)	Liquid Adhesive
Insulation (2).....	
Location (2).....	
Connection (2)	
Insulation (3).....	
Location (3).....	
Connection (3)	
Vapor Barrier	Foil Backed Drywall
Location.....	Exterior of Backup
Continuity	Not Specified
Acc. Vapor Barrier.....	
Air Barrier .....>	Not Specified
Location.....	Not Specified
Continuity	Not Specified
Cavity Size (mm)	50 mm
Interior Finish.....	Painted Drywall

Air Barrier

1 - No Information
2 - Not Applicable
3 - Not Specified
4 - Other (Specify)
5 - Painted Drywall
6 - Foil-backed Drywall
7 - Parging
8 - Liquid Sealant
9 - Rubber Membrane

For this menu, the meanings of the first 4 choices are presented in Section C.2 of Appendix C which contains instructions for using the programme.

Selection of P transfers the user to the second type of data base through the following initial menu.

Building Problem Survey

Problem Menu

1 - Add a Problem to List
2 - List/Edit/Delete Problems
3 - Print Problems
X - Exit

Choice of No. 1 produces the listing of the 19 problems shown below:

Building Problem Survey

Enter a Problem

1 - Moisture
2 - Interior Staining

3 - Cracking
4 - Spalling/Crushing
5 - Mortar Deterioration
6 - Loose Components
7 - Corrosion
8 - Displacement
9 - Mould/Mildew
10 - Blistering of Coating
11 - Efflourescence/Staining
12 - Drafts
13 - Broken/Cracked Glass
14 - Noise/Vibration
15 - Icicles
16 - Heat Problems
17 - Insulation Saturation
18 - Weakening of Sheathing
19 - Parking Garage Problems

Selection of any one of these problems produces a listing of possible types of information relevant to that problem and for each type of information, a menu pops up to provide choices for the input. Using a Moisture problem as an example and Type of problem for the menu, the figure below illustrates typical input.

Moisture Problems

Type of Problem.....	Rain Leakage
Location on Building.....	Top 1/4 of Building
Exposure	No Information
Location of Moisture	Ceiling
Occurs With.....	Rain
Time of Year	April to November
Severity	Severe
No. of Units Affected.....	4-8
Possible Causes.....	Inadequate Design
confidence of Cause.....	Medium (Reasonably Sure)
	Comment
	Done

No Information
Not Specified
Not Applicable
Other (Specify)
Condensation
Rain Leakage
Surface Water
Ponding
Unknown

Comment: Condensation, rain leakage, staining and deterioration of drywall are common on the top floor around the skylights.

2.1.4 Searches for Comparison or Correlation Studies

The logic for various types of searches is briefly discussed in Section C.5 and one of the following options must be chosen when item 3 on the Building Problem Survey is selected.

1 - All Details/All Problems

2 - All Details/Any Problem

3 - Any Detail/All Problems

4 - Any Detail/Any Problem

The form of output must be chosen from the following when item 4 of the Building Problem Survey is selected.

1 - Number of positive cases

2 - Addresses of positive cases

3 - Addresses and comments on positive cases

2.2 Rationale for Various Types of Searches

2.2.1 Simple Combinations

Using only the data describing the buildings it is possible to list and/or count the number of buildings that have a particular characteristic such as brick veneer, a particular group of characteristics such as brick veneer, steel stud backup and no horizontal movement joints, or a group of buildings that contain one of a number of characteristics such as no horizontal movement joints or no cavity flashing or no weepholes. This is useful for quantifying information on aspects such as various forms of construction, building practices, locations of buildings.

2.2.2 Matching Combinations

For buildings searched for a specified set of details, those that also have specified problems can be identified. For example buildings with brick veneer and no horizontal movement joints can be searched to see which have spalling of the veneer. The search will provide the number of matches out of the total number of buildings conforming with the description (i.e. 12 matches out of 25). Variations on this type of matching to identify buildings possessing at least one of a group details and some particular problem or set of problems or one of a group of problems are also accommodated. Listing of the buildings and of the problems can be printed or reviewed on the screen if desired.

These type of searches are most useful for comparison and correlation studies. For comparison studies two searches might be done to obtain information on the relative frequency of some problem, or set of problems, or one of a number of problems. An example might be comparison of moisture problems of buildings with brick veneer built in the Ottawa area versus those built in the Hamilton area.

2.2.3 File Retrieval System

The very existence of building design and construction details and building problems in a well organized and consistent format for each building is a very useful tool for review of files on a particular building.

3. ANALYSIS OF DATA FROM THE BUILDING PROBLEM SURVEY

3.1 Introduction

A major part of the work of this project was to develop a system for collecting and studying data on design and construction details and on building problems. Another major part was the actual collection and listing of this data. Both of these activities have been completed and are available for use on the floppy disk enclosed with this report. In this regard, to a large extent the written report is redundant information. However, in addition to the hard copy of the instructions for using the programme (also available on the disk), a hard copy of the programme listing is included in Appendix A. This is useful for review of some of the options available and as background for future modifications or additions to the programme.

A large variety of simple listings, comparative studies and correlations have been run. Except for the simple numerical count of frequency the other levels of output generate large files. The best place to review these files is on the screen of the computer. However, to illustrate some of the types of comparisons and correlations, some of the outputs have been reproduced in Appendix B.

Brief comments are provided below on some of these studies.

3.2 Overall Problem Distribution by Regions.

The following table is a summary of the problems listed according to region in Ontario. The total distribution of problems is shown graphically in Figure 1.

Summary of Problems by Regions

Problem	Region		
	Ottawa	Toronto	Hamilton
Moisture	7	23	6
Interior Staining	3	7	2
Cracking	3	12	4
Spalling	1	0	0
Mortar Deterioration	0	3	0
Loose Components	0	3	1
Corrosion	3	2	3
Displacement	2	1	0
Mould/Mildew	0	1	0
Blistering of Coating	0	0	0
Exterior Staining/Efflorescence	5	13	3
Drafts	2	11	0
Any Problem	7	25	8
Total Number of Buildings with Problem files	8	28	8

3.3 Specific Detail and Problem Correlations

3.3.1 Flashing Details

Of 30 buildings that had flashing details 14 showed the flashing extending beyond the face of the wall, 12 showed it flush with the wall and 4 showed it terminating within the wall. In terms of matching moisture problems, the respective numbers of 9, 12 and 4 would seem to indicate a correlation with lower occurrence of moisture problems with proper flashing details. This is shown in Figure 2. However, study of the type of moisture

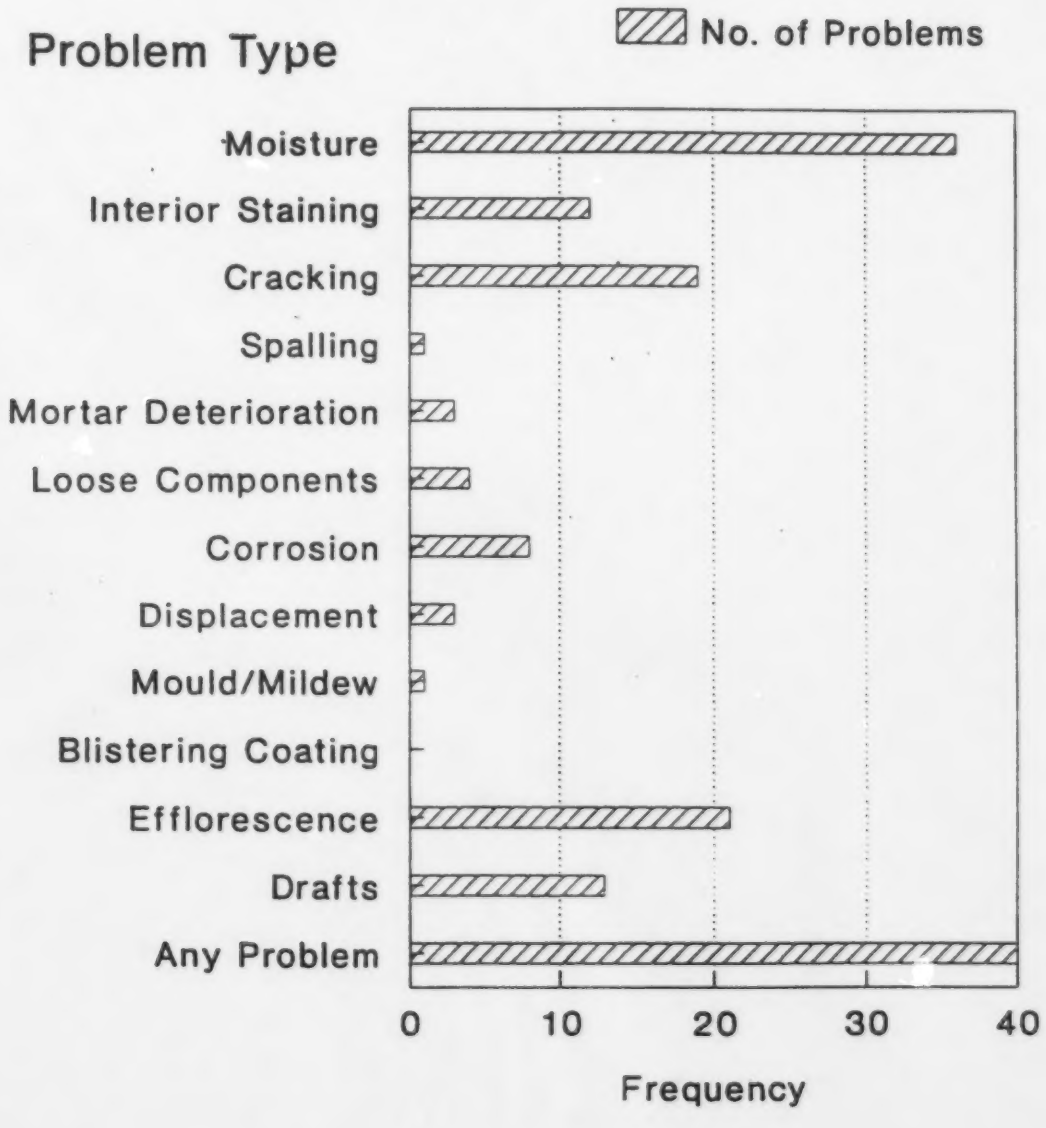

FIG. 1 FREQUENCY OF PROBLEMS

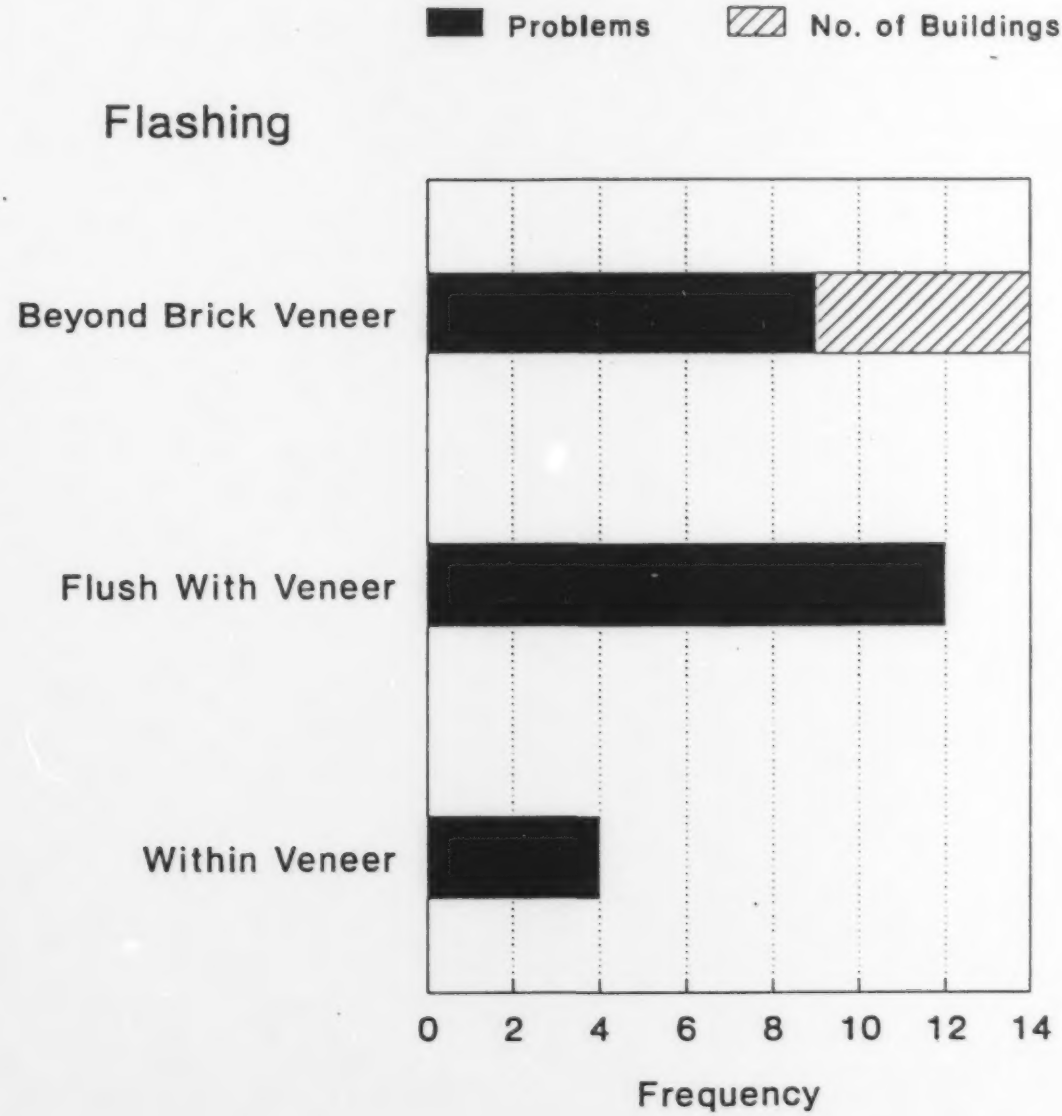

FIG. 2 TYPE OF FLASHING DETAIL VS. MOISTURE PROBLEMS

problem makes this less apparent because some of the moisture problems could not be directly related to flashing details. The photograph in Fig. 3 indicates not only lack of flashing but also extension of the foundation beyond the face of the veneer. Both this plus lack of proper flashing can produce leakage. Alternately as shown in Fig. 4, problems due to overflow from the roof are unlikely to be very directly related to the flashing or wall type.

3.3.2 Clay Brick Veneer, Moisture Problems and Staining

Figure 5 is a bar chart showing frequency of moisture problems for various wall systems. Of the 23 buildings identified with clay brick veneer 22 experienced some form of moisture problem and 6 of these also exhibited exterior staining (efflorescence) such as shown in Figure 6. The frequency of moisture problems and staining versus specified cavity size is shown in Fig. 7. Two out of 11 matches were for buildings with specified cavities of 25 mm or greater and the others were for cavities less than 25 mm or no information. The actual cavity widths are not known.

3.3.3 Brick Veneer with Moisture Problems for Different Backup Walls

Of 23 buildings with brick veneer 22 had moisture problems. These were broken down as 7 out of 7 for steel stud backup, 13 out of 14 for concrete block backup and 2 out of 2 for wood stud backup. These relationships were shown in Fig. 5. However review of the type of moisture problems reveals that in many cases the problem was not related to the type of backup wall. As shown in Fig. 8 for a solarium, the total reliance on caulking to prevent rain penetration and air leakage is a common fault.

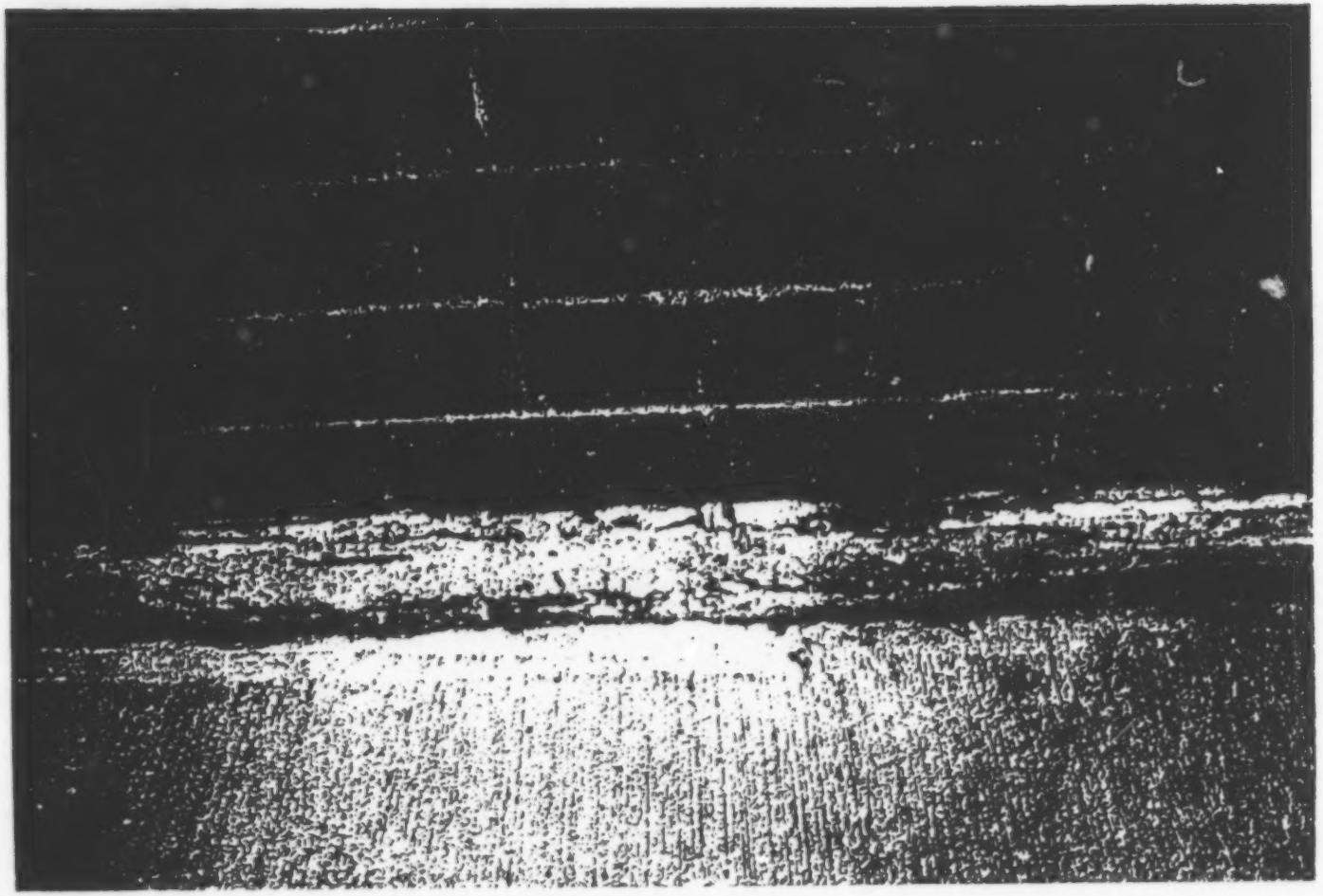

FIG. 3 PHOTOGRAPH OF FOUNDATION EXTENDING BEYOND FACE OF VENEER

FIG. 4 PHOTOGRAPH OF WATER FLOWING OFF OF ROOF AND ON TO THE VENEER

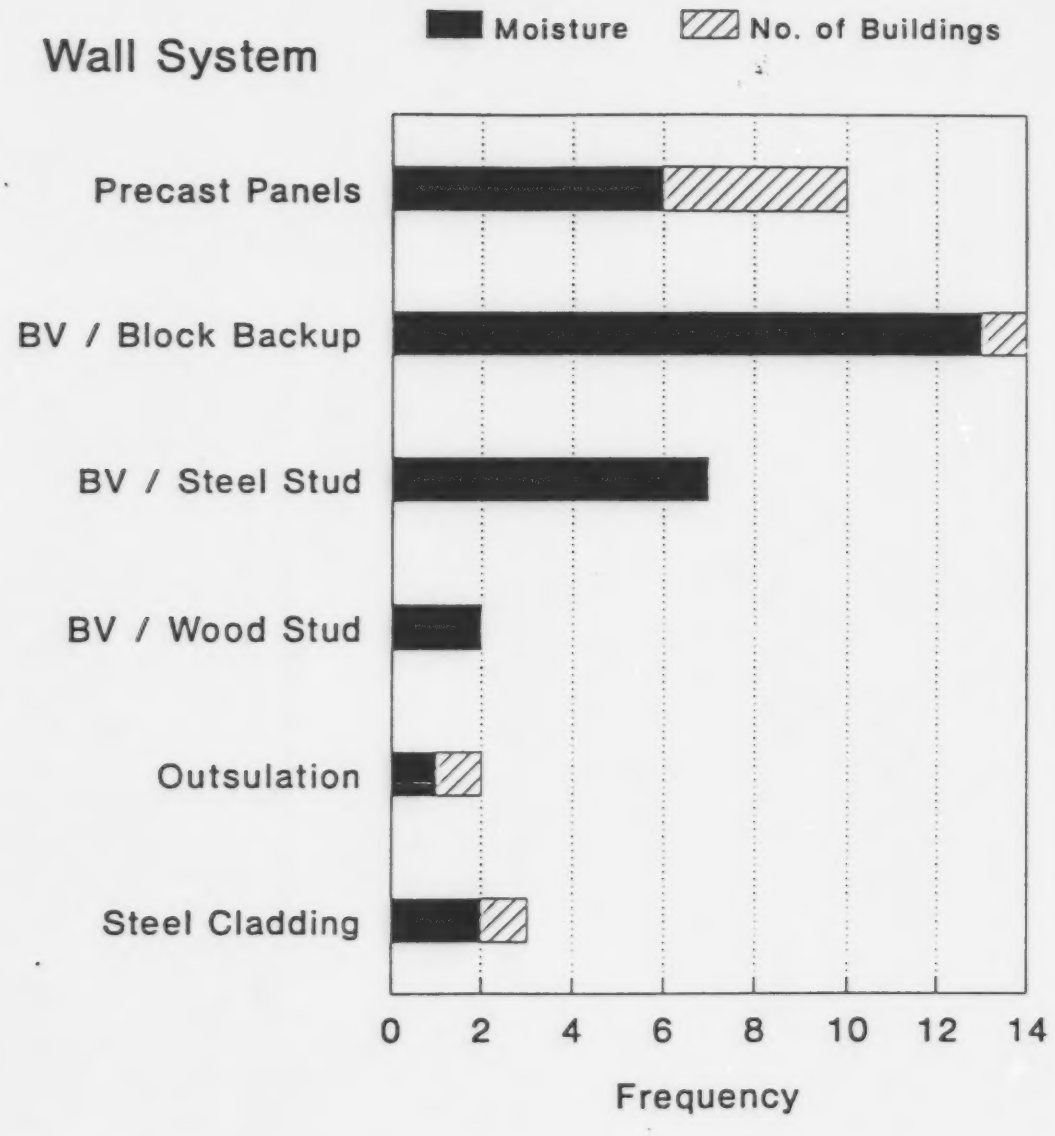

FIG 5 FREQUENCY OF MOISTURE PROBLEMS WITH VARIOUS WALL SYSTEMS

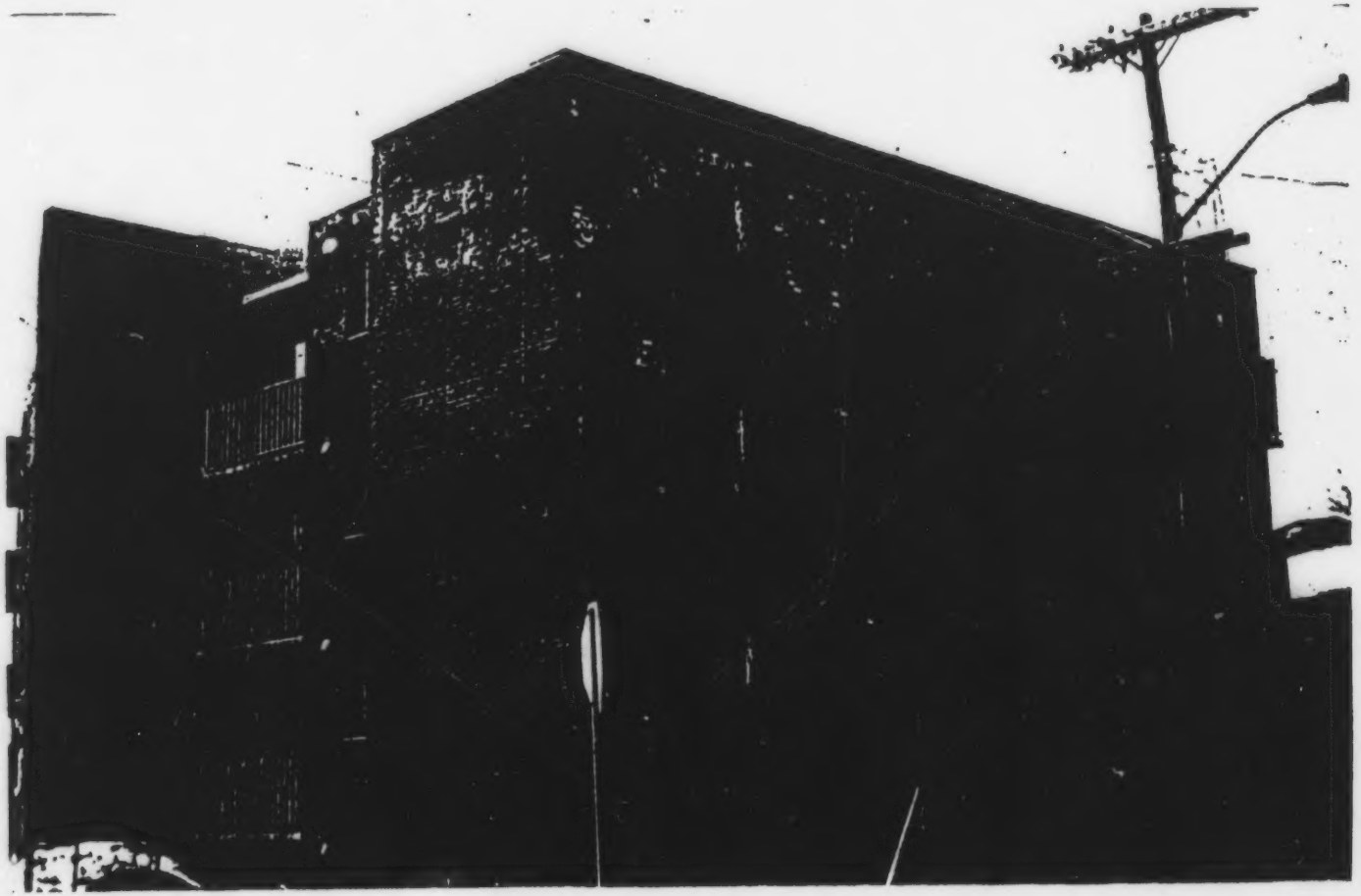

FIG. 6 EXAMPLE OF SEVERE EFFLORESCENCE

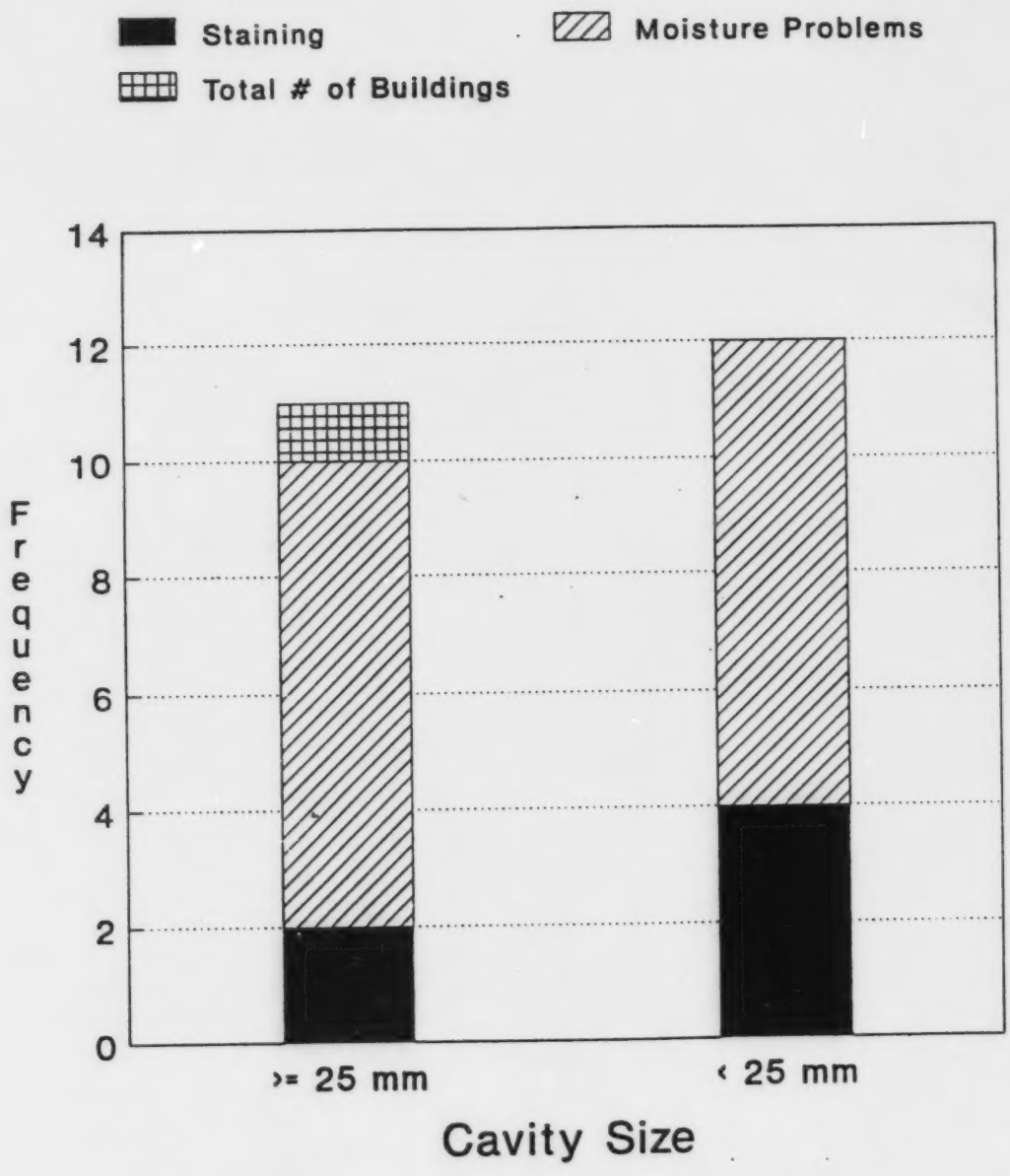

FIG. 7 FREQUENCY OF STAINING AND LEAKAGE VERSUS SPECIFIED CAVITY SIZE

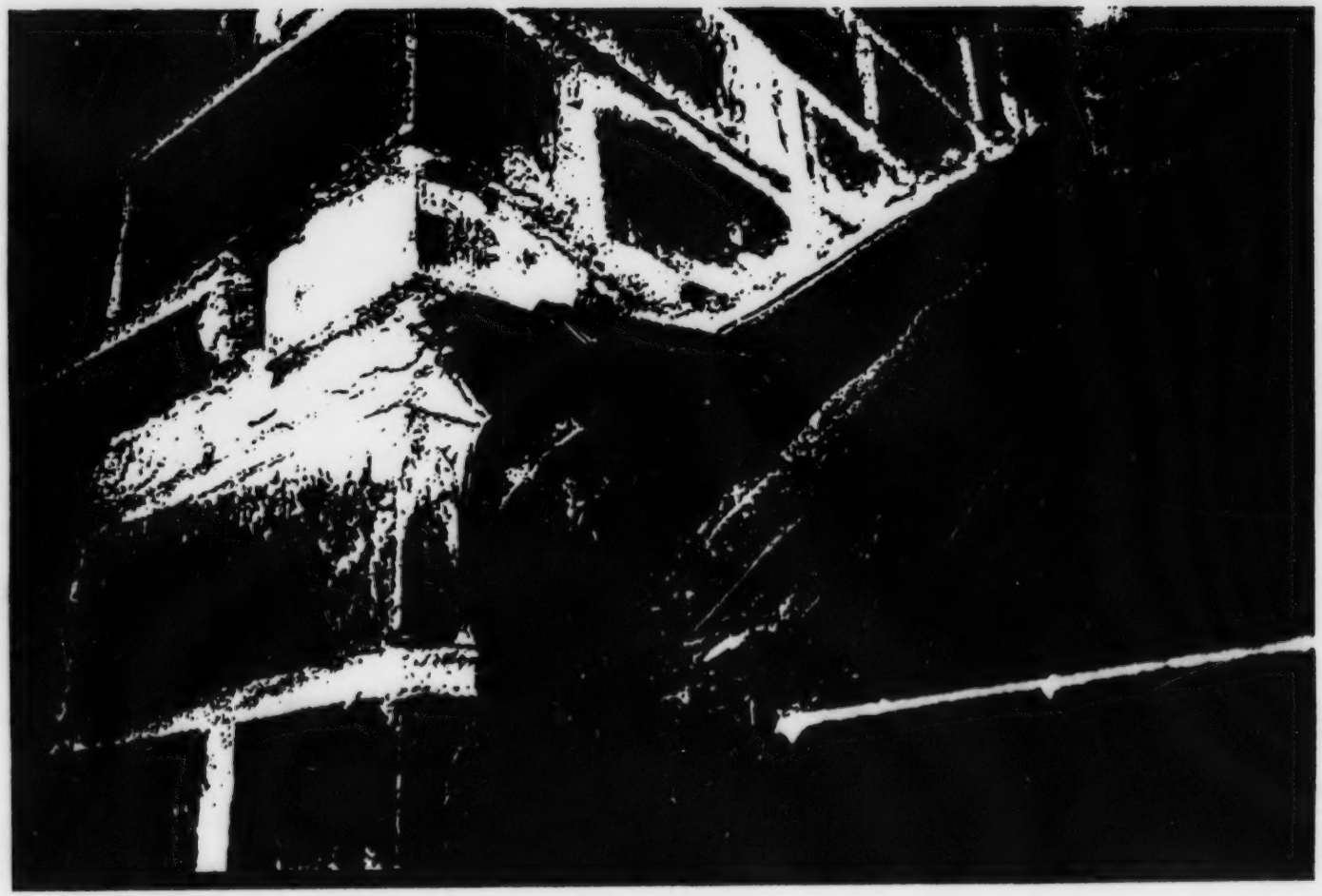

FIG. 8 SEALING OF SOLARIUM TO EXTERIOR WALL USING CAULKING

3.3.4 Distribution of Type of Flashing for Brick Veneer

For the 23 cases, 11 were not specified, 6 were "rubber like", 2 were paper backed copper, 3 were copper and 1 was galvanized. It is expected that the copper was also intended to be with some form of backing material.

3.3.5 Distribution of Cavity Sizes

No cavities 50 mm or greater in width were specified but 12 between 25 and 49 mm were specified. Of the remaining walls, 2 were specified as less than 25 mm, 5 were not specified and there was no information for 4.

3.3.6 Specification of Horizontal Movement Joint Under Shelf Angle

Of the 21 buildings, a specific gap was specified 15 times, 1 joint was shown mortared in and 1 had no gap while the remaining 4 were not specified. This distribution is shown in Fig. 9. In several cases it is known that the specified gaps were not provided but not enough site visits were made to provide a statistical base. It was also very common to find that vertical movement joints were missing. Fig. 10 shows the lone vertical joint found in one building.

3.3.7 Type of Air Barrier

For the 44 buildings, the air barrier location was not specified in 23 cases whereas painted drywall was specified 17 times. A liquid sealant was specified with insulation 3 times and a "rubberized" membrane was specified once. The frequency distributions of these specifications is shown in Fig. 11. For the painted drywall air barrier detail for sealing of the barrier was omitted in 6 cases. The lack of effective air barriers resulting in

H. Movement Joint

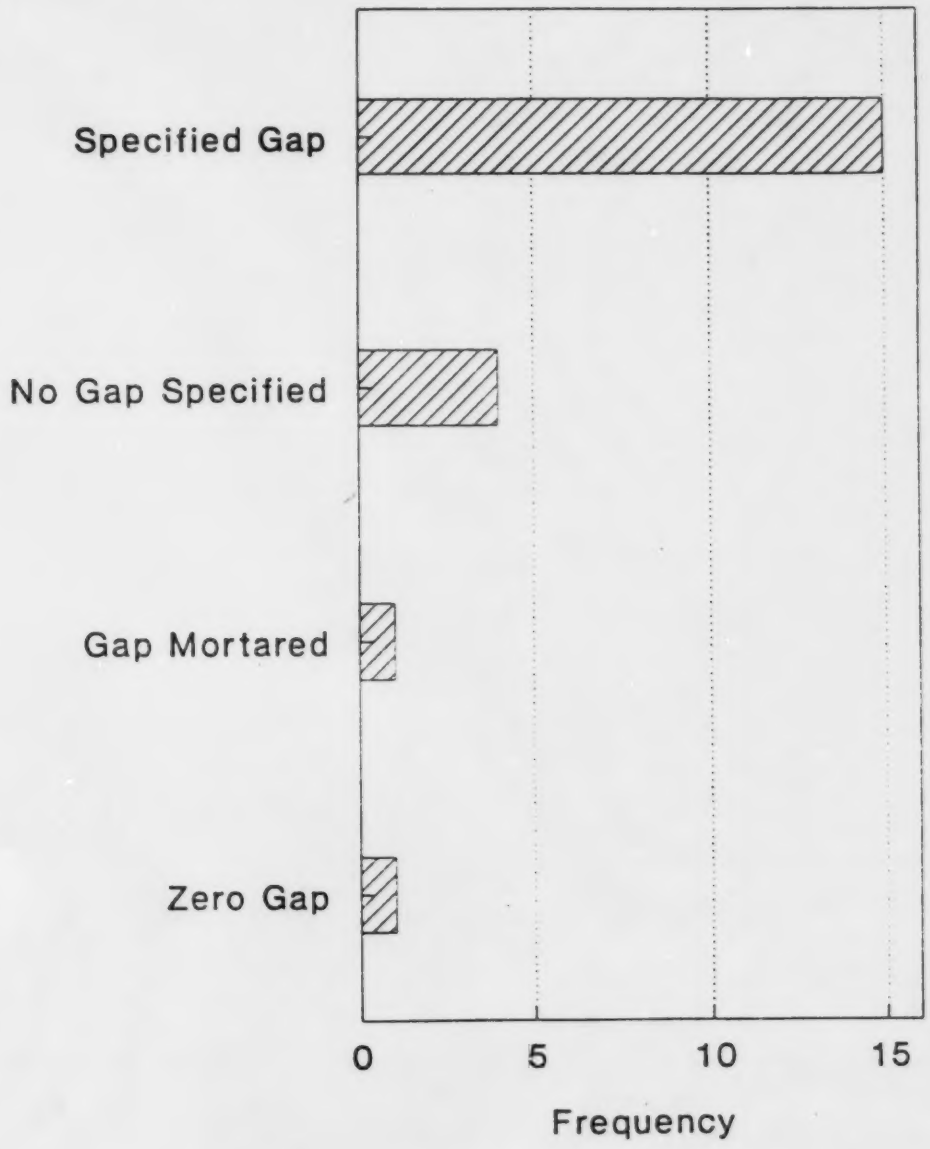

FIG. 9 FREQUENCY OF SPECIFIED HORIZONTAL MOVEMENT JOINT IN BRICK VENEER

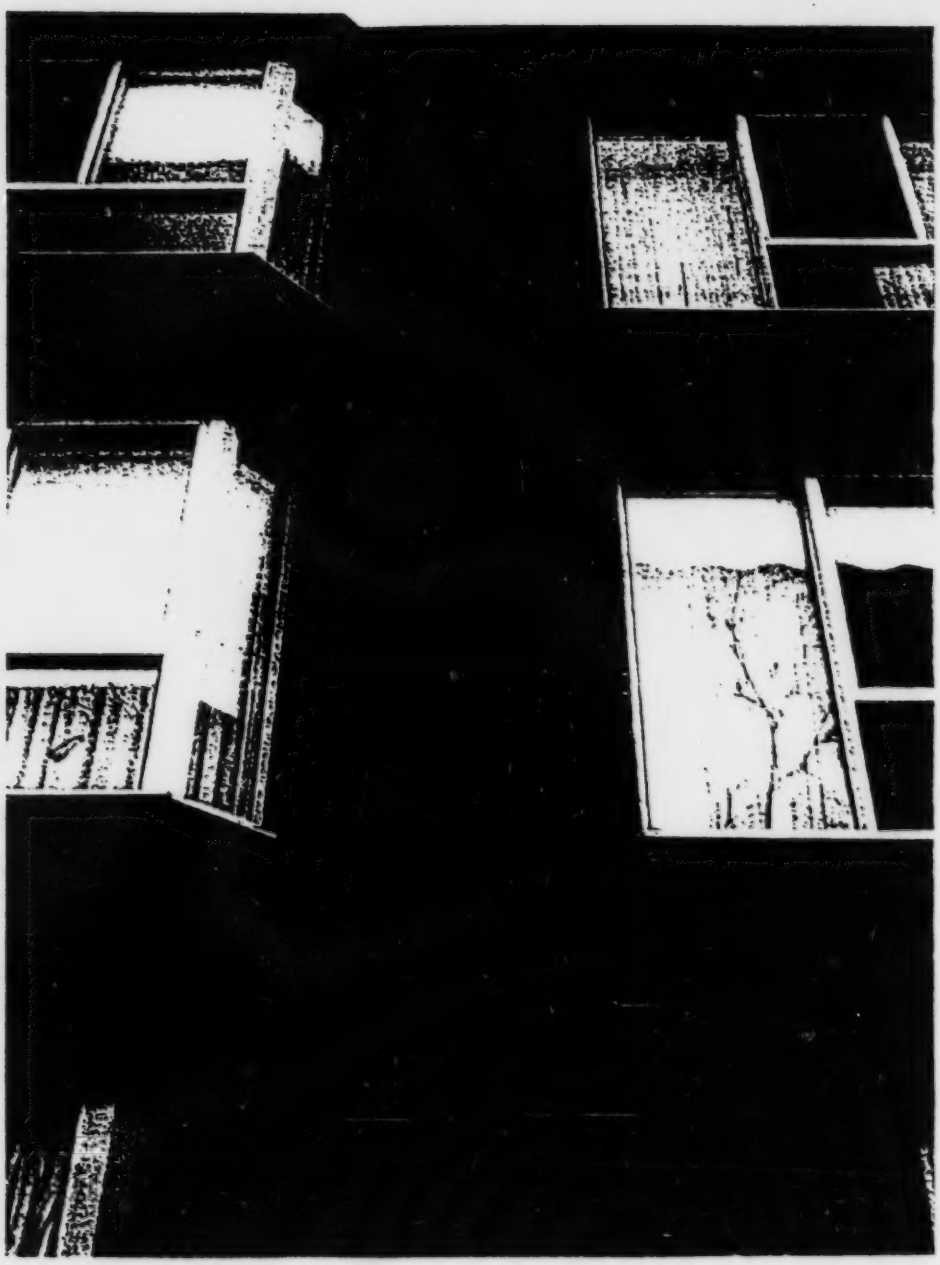

FIG. 10 LONE EXAMPLE OF VERTICAL MOVEMENT JOINT IN ONE BUILDING

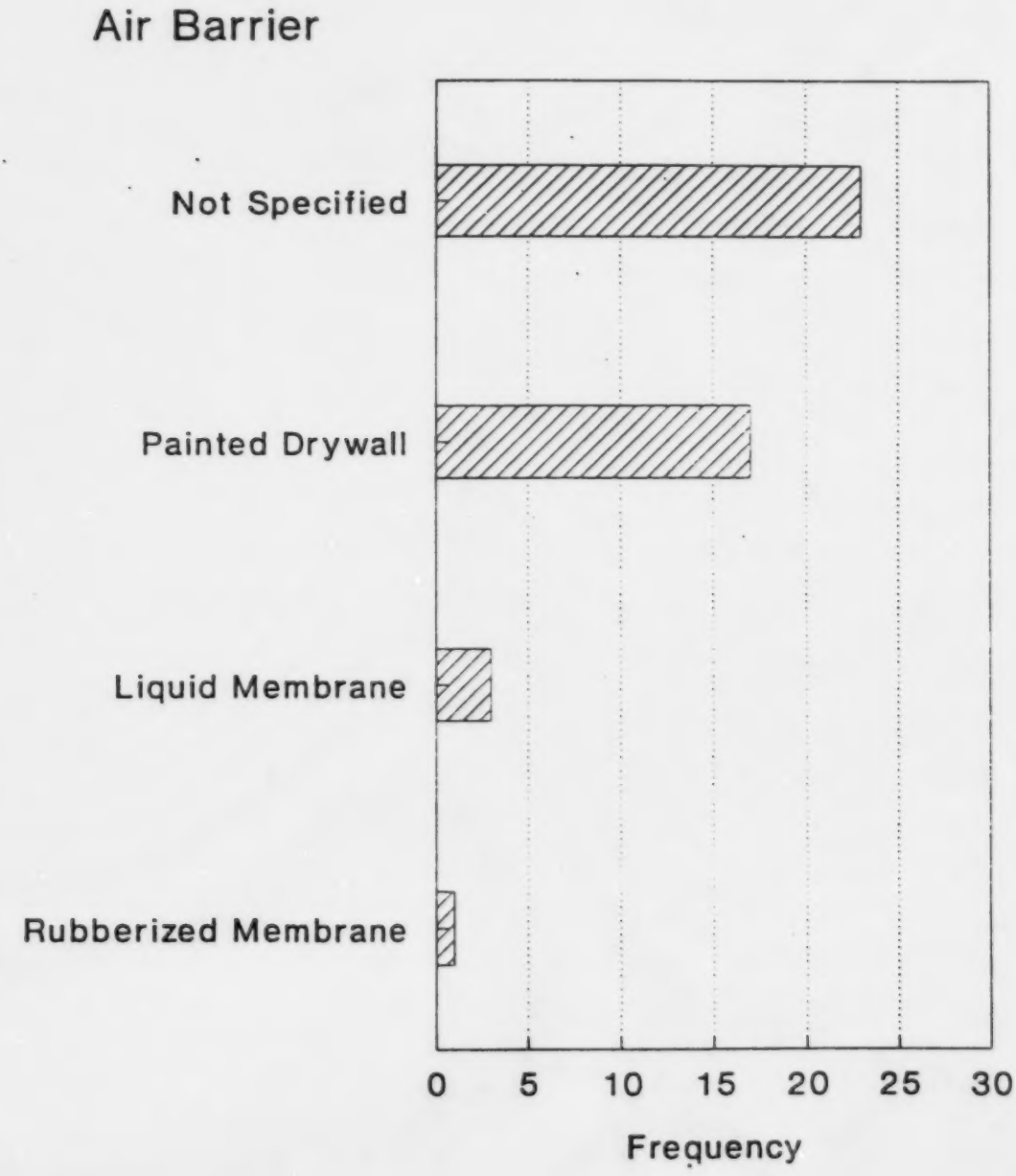

FIG. 11 FREQUENCY OF SPECIFICATION OF TYPES OF AIR BARRIERS

condensation of moisture from exfiltrating moist air is a major cause of efflorescence and spalling as shown in Fig. 12.

3.3.8 Sealing of Air Barrier According to Type of Backup Wall

Of 22 walls with steel stud backup, the sealing of air barrier was not specified 13 times compared to 11 times out of 15 for block backup walls. Liquid air barriers with rigid insulation was specified twice for steel studs and once for block backup. Caulking was specified as the seal 7 times for steel studs and 3 times for concrete block backup. This distribution is shown in Fig. 13.

3.4 Conclusion

As was indicated at the beginning of this section, a large number of combinations of building details and problems can be compared and correlations attempted. However, interpretation of these results should be done in conjunction with output containing descriptions of the problems and comments on the probable cause of the problem.

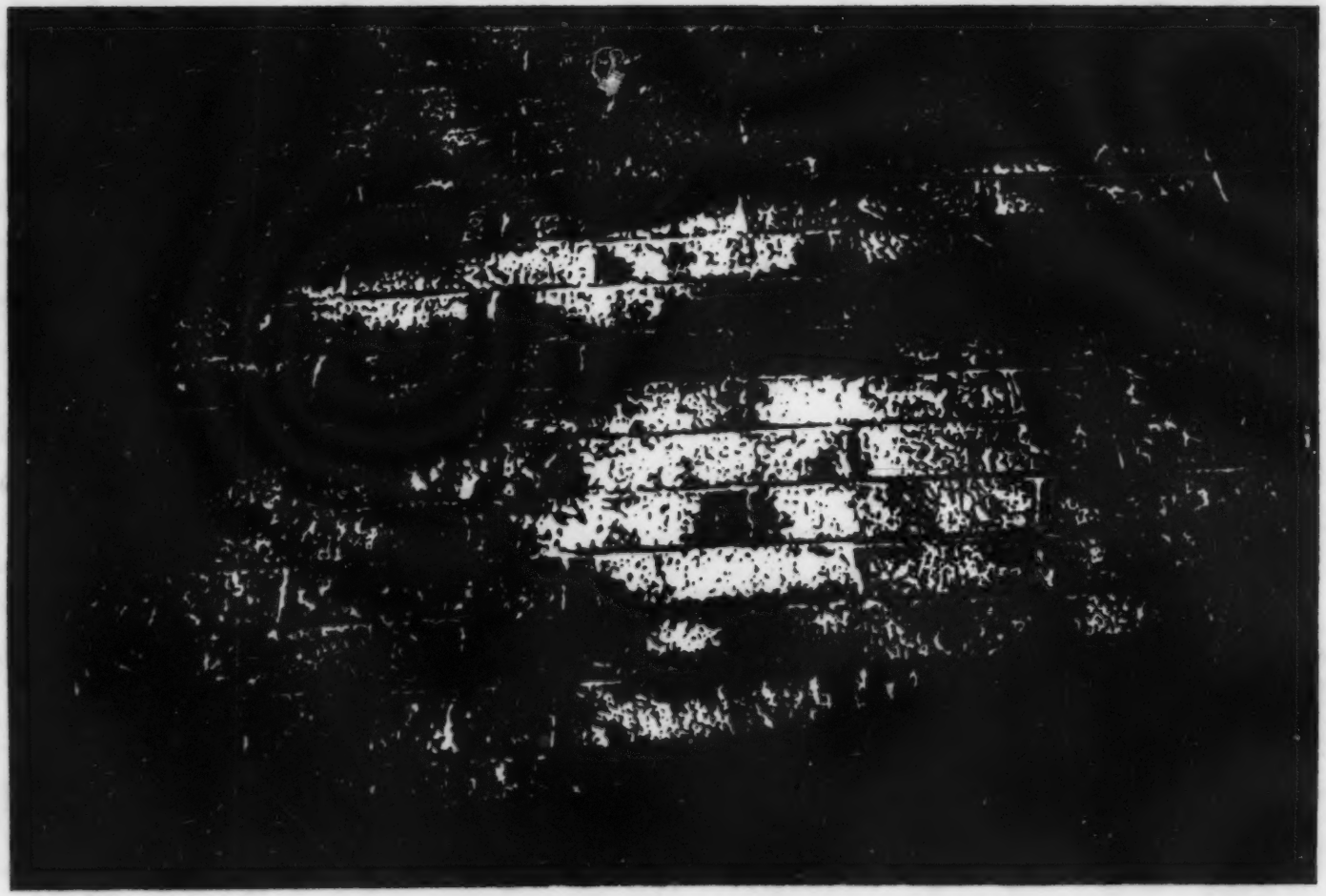

FIG. 12 EXAMPLE OF EFFLORESCENCE AND SPALLING

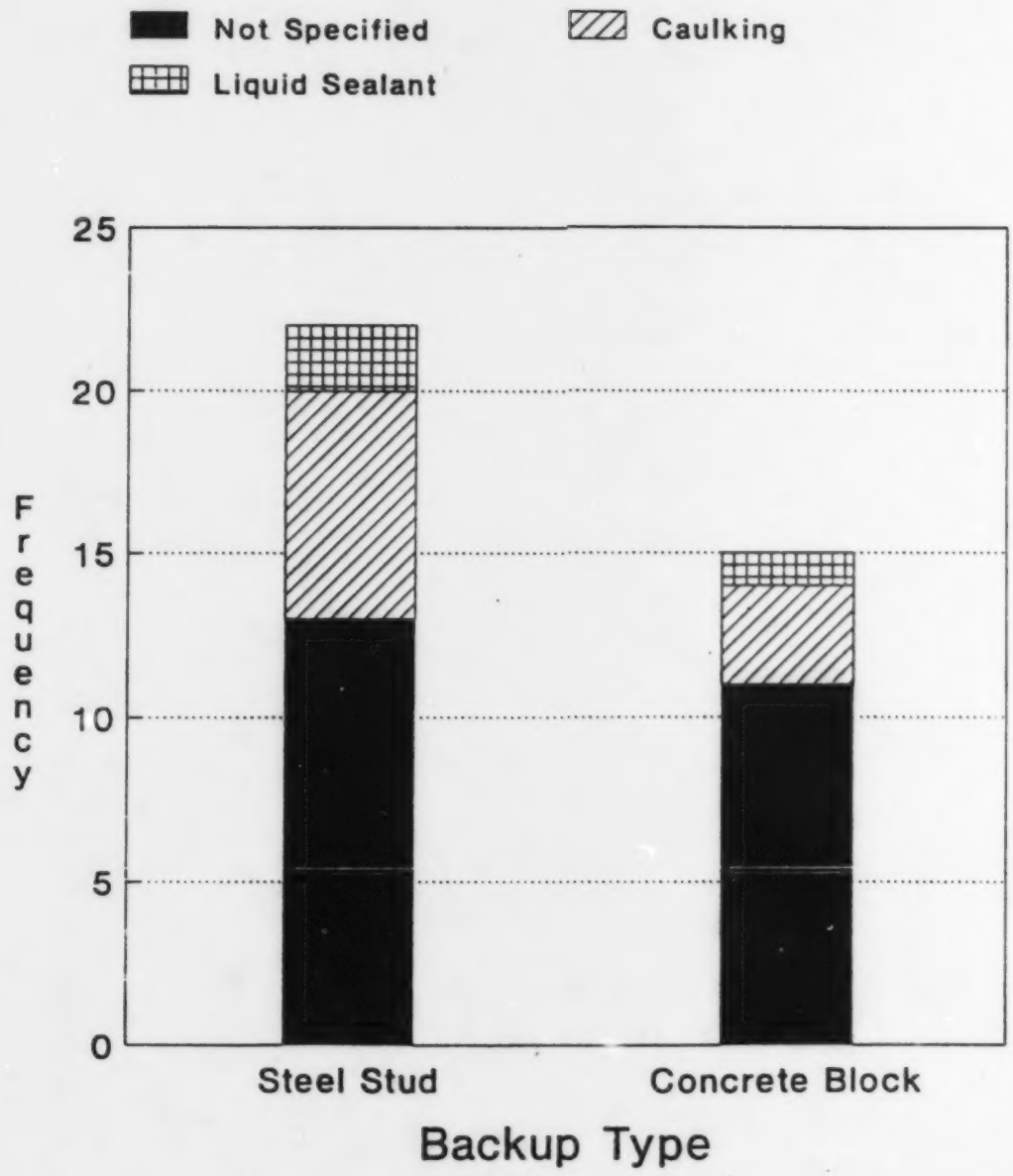

FIG. 13 FREQUENCY OF SPECIFICATION OF METHOD FOR SEALING AIR BARRIER VERSUS TYPE OF BACKUP WALL.

4. OBSERVATIONS

4.1 Design and Construction Details

Following review of 47 sets of plans, the most obvious observation is that the vast majority were deficient in providing sufficient details to guide the builder. Designers may have the mistaken impression that reference to Standards or reliance on standard good practice will suffice. However, particularly for the building envelope, appropriate construction standards do not exist and good practice is not well defined.

In a couple of cases very comprehensive sets of plans were reviewed. Aside from the well organized presentation, the outstanding feature of these plans was the clear detailing of critical aspects of construction. A special effort was made to visit these buildings and it was interesting to note that the quality of construction and general interior and exterior appearance matched the quality of the plans. The ONHWP files for these buildings were essentially empty.

4.2 Inspection

Complete details of inspections by the designers were not available but from the information available it appears that they were generally infrequent and likely not very effective for quality control. Discussions with local building officials indicate that they do not have sufficient budgets or manpower to carry out detailed plans review and site inspections on items such as the building science features of building envelopes. Although they will point out obvious deficiencies, their main focus is likely to continue to be related to structural and fire safety. Therefore, since it is not likely that additional tax dollars will be allocated to this area, it does not seem realistic to depend on building inspectors to ensure compliance with design provisions to minimize problems such as rain penetration and concealed condensation.

An attempt was made to correlate changes in frequency of problems with the introduction of the provisions of the ONHWP's Bulletin 19. Unfortunately, it appears that implementation of this construction review procedure is too recent for the effects to be obvious. However what was apparent is that the Final Audit Reports did provide an improved identification of problems.

Where Technical Audits were commissioned by Condominium Boards, it is not surprising that these provided the most exhaustive and detailed identification of problems. It might be expected that where the audit is paid for by the Contractor, there is some pressure not to be as uncompromising. Comparison of reports sponsored by the two parties with vested interests demonstrates this divergence. Development of a policy of inspection and review by qualified firms not directly responsible to either the contractor or board might be worth considering as a way of avoiding either omission of some problems or exaggeration of others.

4.3 Quality of Construction

Although some aspects of poor quality of construction can be linked with inadequate plans and specifications, other features such as alignment, finishing, and even following the plans must be associated with the capabilities of the contractor. It is unlikely that a successful house builder will be an immediate success in construction of multi-storey buildings. It may be worth considering different warranty rates depending upon the experience and track record of the contractor. Alternately different levels of third party inspections paid by the contractor by administered by others would likely result in much improved quality.

5. CONCLUSIONS

1. The spreadsheet programme developed for this project has proven to be a very effective tool for organizing a consistent documentation of building details and building problems. It also provides an efficient mechanism for studying building trends and identifying recurring problems. Comparisons and correlation studies are also easily performed. It appears that this initial work may serve as a useful base for other studies and, as suggested in Section 6, further development as an existing tool for ONHWP and CMHC may be worthwhile.
2. The standard of detailing, particularly for factors related to the building envelope, is generally not satisfactory.
3. The standard and frequency of inspection, particularly for factors related to the building envelope, is generally not satisfactory.
4. The problem files are currently limited to problems identified over the period of the warranty. From study of existing problems and from review of design deficiencies, additional problems, in many cases quite severe, should be expected. For example, problems caused by the omission of movement joints under shelf angles are unlikely to be evident within one or two years but cracking, spalling and even failure of veneer panels have been known to occur as long as 10 to 15 years after construction.
5. Corrosion, decay, growth of fungi and many other types of deterioration are long term durability problems. In many cases the progress of this deterioration may not be evident from single reporting of problems such as leakage around windows. In other cases there may be no externally visible evidence until the deterioration is well advanced.
6. Although parking garages were not an intended part of this study, the very common recording of problems in the ONHWP files led to provision of a separate section in the

spreadsheet program to permit this information to also be included. It is quite apparent that basic errors in design and construction are still frequently encountered.

7. The lack of adequate detailing on most of the drawings reveals a major need for improvements in this area. For example not only are the locations of movement joints required but also the method of building them. The same situation applies to continuity of air barriers and rain screens at openings and at intersections with other building elements.

8. To some extent the sophistication of the programming for documentation of problems is not matched by comparably detailed descriptions of past problems. Therefore the conclusions from the correlation and comparison studies are limited to being relatively general in nature. Also, because some of the comparisons are not statistically reliable, reporting of these could lead to unsupportable conclusions. Over the short term, moisture problems are by far the most common problem. The data does not clearly show any difference between frequency of occurrence for steel stud versus concrete block backup walls when the specific types of problems are considered. For instance leakage around windows does not seem to be affected by the type of backup wall for brick veneer. Similarly the specification of a movement joint under a shelf angle is not affected by the type of backup wall.

   Following moisture problems, exterior staining (efflorescence), cracking, and drafts make up the other commonly identified problems. For problems which are only likely to be seen after several years, such as spalling, the records are consistent with this expectation.

6. RECOMMENDATIONS

1. It is important that designers be required to provide comprehensive and well detailed plans and specifications. As a part of efforts to ensure that this happens it is recommended that designers be required to fill in the design and construction details spreadsheet data file prepared as part of this project. This record will provide the ONHWP with an easily referenced file of exactly what was built and will allow future studies of building trends and possible comparisons and correlation studies with problems.
2. It is in the interest of the Ontario New Home Warranty Program and CMHC to maintain well documented and standardized problem files so that problem areas causing the greatest trouble and cost can be identified. This information will help in planning on use of manpower and budgets for improving the quality of residential construction. Therefore it is recommended that the ONHWP and CMHC staff enter and update problem data on buildings under their jurisdiction using this part of the spreadsheet data file. Not only will this information be useful for general purposes but it will also serve as a useful retrieval system for continued monitoring of the progress of a building for conciliation meetings, and other discussions.
3. If the ONHWP and CMHC see merit in the above recommendation it is recommended that additional funding be provided to strengthen and extend the problem data side of the spreadsheet programme. In this regard it is suggested that a finer breakdown of problems be defined where, for example the current Moisture Problem file could be divided into 4 or 5 different moisture problems. In addition it would be useful to be able to conduct searches for comparisons or correlations using a more in depth search of the problems in a manner similar to the design and construction details side of the programme. For example, rain penetration at a particular location and of a particular severity could be examined in conjunction with building details or other problems.

4. Another helpful feature for management of a building file would be to create a flag system to identify problems that were to be corrected so that follow up would be timely. Completion of remedial work would be recorded and result in removal of the flag. The existence of this standardized electronic file system would help staff to review their cases and in the event of illness or resignations would make it easier for others to take over this work. Files for tracking costs and payments would also be useful.

5. It is essential that programmes be developed to help designers acquire the necessary knowledge to produce satisfactory designs. It is recommended a continued effort be placed on practical education and on production of easy to read easily accessible technical information. Illustration of typical good practice details in a form suitable for copying or modification would be a useful tool to many designers.

6. The implementation of the Bulletin 19 "Design and Site Review Reporting" appears to be a good idea. However to be effective, rigorous enforcement will be required. Provisions to ensure that the inspections are more independent of the contractor would lend more credibility to this programme. It is recommended that this aspect be considered.

7. As a coordinated effort with Part 5 of the National Building Code and the Ontario Building Code, it is important that construction and design standards referenced in Part 4 of these codes also contain requirements related to the performance of the building envelope. The current work by CSA Technical Committee A371 "Masonry Construction for Buildings" to provide such guidance should be followed by other committees dealing with the use of other building envelope wall and roof systems. It is recommended that ONHWP and CMHC encourage and participate in such developments.

8. Although the study of problems in parking garages was not intended to be part of this project, the very frequent observation of problems in this area at very early ages of the

buildings is a clear indication that many designers and builders involved in this condominium type of construction have not adopted adequate practices. It is recommended that efforts be continued to get existing information into the hands of those involved and that the requirements for proper design and construction to minimize problems be enforced.

9. The computer program for documenting design details and identified problems is suitable for use by building owners such as Provincial Housing Authorities. In most cases these authorities continue to monitor the performance and repair and maintenance costs of their buildings over many years. The availability of data from these additional sources and over the longer period would be very useful in identifying other major problems, particularly those requiring longer times to become evident. It is recommended that other private and public building owners be invited to participate in documentation of such problems. The benefits of the analysis of these efforts should also be shared with these other interested parties.

10. The need to correct existing problems and to repair damage should be considered an important area for participation by CMHC and the ONHWP. It is recommended that guidelines and typical remedial measures be developed to help ensure that such activities are effective. Schedules and requirements for normal maintenance and repair should also be included.

11. At the present time, the problems most evident in new multi-storey residential construction are related to rain penetration and to moisture condensation in walls. Although considerable information regarding proper design and construction practices is available, it is obvious that efforts to achieve effective technology transfer must be continued. It is recommended that ONHWP and CMHC continue to place a large emphasis on development of appropriate forms of information to reach those who are currently not following good practices related to these major problem areas. Co-operative efforts with professional and trade organizations may be a partial solution.